

REMARKS

I. Introduction

With the addition of new claims 21 to 26, claims 9 to 26 are pending in the present application. In view of the foregoing amendments and the following remarks, it is respectfully submitted that all of the presently pending claims are allowable, and reconsideration is respectfully requested.

II. Telephone Interview

Applicants thank the Examiner for the courtesies extended during the course of the telephone interview with Applicants' representative on November 4, 2003.

During the course of the interview, a proposed new claim was discussed.

During the course of the interview, European Published Patent Application No. 0 748 949 ("Hofmann et al."), British Published Patent Application No. 1 341 087 ("GB '087") and U.S. Patent No. 4,971,456 ("Hori") were discussed.

The principal proposed amendments discussed during the course of the interview related to the addition of a new claim 21, which is attached to the Interview Summary dated November 6, 2003.

The general thrust of the principal arguments presented during the course of the interview included: (1) under the unity of invention rules, a request for election of species is improper in the present national stage application; and (2) the claims of the present application are patentable over the references relied upon for at least the reason that the references relied upon fail to disclose a vibration damper arranged **inside** a rotatable shaft.

Other pertinent matters discussed include suggested amendments to the drawings and the Specification for clarification purposes and suggested amendments to the proposed new claim.

III. Amendments to the Drawings

As suggested by the Examiner during the course of the interview, Figure 1 has been canceled herein and new Figures 1a, 1b, 1c and 1d have been added herein. Each of Figures 1a, 1b, 1c and 1d illustrate a respective exemplary embodiment previously illustrated in quadrants I, II, III and IV in Figure 1. In

addition, section lines have been added to Figures 1a and 1b to indicate the cross-sectional planes of Figures 2 and 3. No new matter has been added.

IV. Amendments to the Specification

The Specification has been amended herein to conform to the amendments to the drawings and to make more clear that which is illustrated in the Figures. In accordance with 37 C.F.R. § 1.125(b), the Substitute Specification (including the Abstract) contains no new matter, and as required by 37 C.F.R. §§ 1.121(b)(3)(ii) and 1.125(c), a Marked-Up Version of the Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Amendment and Response to Request for Election of Species. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

V. Election of Species

The Office Action states at page 2 that “[t]he application contains claims directed to more than one species of the generic invention” and that “[t]hese species are deemed to lack unity of invention because they are not so linked as to form a single general inventive concept under PCT Rule 13.1.” While the Office Action refers to PCT Rule 13.1, it is believed that Rule 13.1 has not be correctly applied and that the requirement for election of species should be withdrawn. As an initial matter, unity of invention was not found to be lacking during the international phase of International Application No. PCT/EP98/04659, from which the present application entered the national phase. In this regard, the Examiner’s attention is directed to, for example, the International Preliminary Examination Report dated September 16, 1999, a copy of which was submitted on February 2, 2000. Furthermore, under Rule 13.2, the requirement for unity of invention is fulfilled where there is “a technical relationship among those inventions involving one or more of the same or corresponding special technical features,” with the expression “special technical features” meaning “those technical features that define a contribution which each of the claimed inventions, considered as a whole, makes over the prior art.” See also, 37 C.F.R. § 1.475(a). Annex B to the Administrative Instructions Under the PCT plainly set forth that in the situation in which a single claim recites alternatives, “the requirement of a technical interrelationship and the same or

corresponding special technical features as defined in Rule 13.2, shall be considered to be met when the alternatives are of a similar nature.” Annex B, paragraph (f). Still further, under Rule 13.3, the determination of whether a group of inventions is so linked as to form a single general inventive concept is to be made without regard to whether inventions are claimed in a separate claims or as alternatives within a single claim. See also, 37 C.F.R. § 1.475(e). In addition, Annex B to the Administrative Instructions Under the PCT plainly states that unity of invention under Rule 13.1 is to be considered in the first place only in relation to the independent claims and not the dependent claims. Furthermore, Annex B to the Administrative Instructions Under the PCT plainly sets forth that under Rule 13.1 “no [unity of invention] problem arises in the case of a genus/species situation where the genus avoids the prior art.”

It is respectfully submitted that the claims of the present application fully comply with the unity of invention requirement in that there is a technical relationship among the several claims “involving one or more of the same or corresponding special technical features,” including the arrangement of a mass body within a rotatable shaft, rubber spring elements arranged to mount the mass body to the shaft and stop elements arranged between the spring elements and arranged between the mass body and the shaft to limit vibration travel of the mass body. In view of all of the foregoing, it is respectfully submitted that the claims of the present application fully comply with the unity of invention requirement under Rule 13.1, and withdrawal of the request for election of species is respectfully requested.

Notwithstanding the foregoing, the Office Action states that the application contains the following species:

Species I	Quadrants I and II; and
Species II	Quadrants III and IV.

Applicants provisionally elect, with traverse for the reasons more fully set forth above, Species I, i.e., the species of quadrants I and II, now Figures 1a and 1b, for prosecution on the merits. It is submitted that the following claims correspond to Figures 1a and 1b: 9 to 12, 15, 17 to 22 and 25. The Office Action states that none of the claims are generic. Applicants respectfully disagree and respectfully submit that claims 9 to 12, 15, 17 to 22 and 25 are generic to the species identified in the Office Action.

VI. New Claims 21 to 26

New claims 21 to 26 have been added herein. It is respectfully submitted that new claims 21 to 26 do not add any new matter and are fully supported by the present application, including the Specification. It is respectfully submitted that new claims 21 to 26 are allowable.

VII. Conclusion

It is therefore respectfully submitted that all of the presently pending claims are allowable. All issues raised by the Examiner having been addressed, an early and favorable action on the merits is earnestly solicited.

Respectfully submitted,

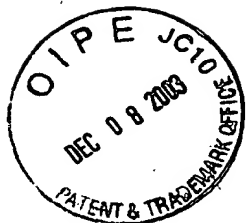
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[10537/68]

Vibration Damper For a Tubular Drive Shaft

Field of the Invention

The present invention relates to a vibration damper for a tubular propeller shaft in the drive train of a motor vehicle having a mass body mounted concentrically in a sleeve by way of rubber spring elements, stop elements that limit the vibration travel of the mass body at least in the radial direction being arranged between the mass body and the sleeve.

Background of the Invention

German Patent DE 36 32 418 on the one hand describes a vibration damper whose mass body is attached directly in a hollow drive shaft by way of a rubber spring element which envelops it radially. Also described is a second vibration damper whose mass body is mounted in a sleeve by way of a rubber spring element which also envelops it. The sleeve is embedded in an elastic layer.

The vibration dampers described here, also called cancelers, are installed principally in propeller shafts or propeller shaft tubes. The propeller shaft tubes are loaded on the one hand in torsion by the drive torque, and on the other hand in bending by their own weight and by the mass effect. They must therefore be not only sufficiently stiff in torsion, but also as light as possible. In order for the vibration dampers with their mass bodies to increase the overall weight of the propeller shaft tube as little as possible, the vibration dampers must be capable of being arranged at the optimum point. That point is, for example, the vibration crest of an interfering vibration that is to be canceled.

At the optimum point, the weight of the mass body can have its minimal value.

Since each propeller shaft, as a flexurally elastic rotor, generally exhibits some imbalance as a result, inter alia, of manufacturing tolerances, the centrifugal force also increases with rotation speed. The propeller shaft thus deflects in the direction of the eccentricity of its center of gravity. In the lower range of rotation speeds usual for propeller shafts, the propeller shaft deflection initially rises in proportion to the centrifugal force component, which is related only to the eccentricity in the center of gravity because the centrifugal force component related to the shaft deflection is still small. Above half the deflection-critical rotation speed, the shaft deflection component quickly increases to a multiple of the component of the eccentricity of the center of gravity. In this range, the known rubber-sprung mass bodies can dangerously amplify the imbalance of the entire structure due to an eccentric displacement in the direction of the eccentricity in center of gravity of the propeller shaft.

Also known, from United Kingdom Patent No. GB 2 073 363 A, is a printing roller in which a rubber-sprung mass body is mounted. For this purpose, the mass body is arranged by way of two rubber rings in a sleeve press-fit into the printing roller. The rubber rings sit at the two free ends of the mass body. Arranged next to each rubber ring is a metal ring which limits the radial deflection of the mass body.

Summary of the Invention

An underlying object of the present invention is therefore that of creating a vibration damper that effectively damps the flexural vibrations of the propeller shaft for specific frequencies without perceptibly increasing the imbalance of the propeller shaft - and thus also the noise emission - in other frequency ranges. As a result of its design, the vibration damper is installable at any desired point with little effort. The installation of multiple vibration dampers can also be possible. In addition, safe vehicle operation is

to be guaranteed even in the event of detachment or breakage of the rubber spring elements retaining the mass body.

5 In an exemplary embodiment of the present invention, the flexible rubber stop elements are arranged - viewed in the circumferential direction - between the rubber spring elements joining the mass body and the sleeve. The stop elements extend over a relatively large circumferential angle as compared with the rubber spring elements, and fill up a large portion of the
10 space located between the mass body, the adjacent rubber spring elements, and the sleeve. Alternatively, the mass body and/or the sleeve are configured locally, in mutually opposite regions - viewed in the circumferential direction - between the rubber spring elements, as stop elements that limit the
15 vibration travel of the mass body at least in the radial direction.

The stop elements limit the mass body excursion to the magnitude necessary in terms of vibration engineering. The
20 vibration dampers damp the vibration excited by the vehicle engine and/or transmission. At the same time, the stop elements prevent any perceptible increase in the total imbalance by mechanically limiting the displacement of the mass body. The noise emission of the drive train is thereby
25 considerably diminished.

The stop elements between the rubber spring elements also prevent any increased imbalance if, for example, the rubber spring elements have broken due to aging and the mass body
30 lies loose in the propeller shaft tube. Without the stop elements, the imbalance additionally generated by the mass body could, in this situation, destroy the propeller shaft.

This also applies to a vibration damper having a mass body
35 arranged in the propeller shaft by way of at least one rubber spring element. In this embodiment of the present invention,

the flexible rubber stop elements are arranged directly between the mass body and the propeller shaft. Here again, the mass body and/or the propeller shaft can be configured locally, in mutually opposite regions - viewed in the circumferential direction - between the rubber stop elements, as stop elements that limit the vibration travel of the mass body at least in the radial direction.

With this embodiment, the rubber spring elements are not braced via a sleeve against the propeller shaft tube. They are adhesively bonded, optionally with a profile to compensate for the bore tolerances of the propeller shaft tube, in the propeller shaft tube. For that purpose, the rubber spring elements and/or stop elements are coated with, for example, an adhesive that bonds in the propeller shaft tube when its walls are heated.

Further details of the present invention are evident from the descriptions below of several schematically depicted embodiments.

Brief Description of the Drawings

Figure 1a shows an exemplary embodiment of a vibration damper in a quartered cross section;

Figure 1b shows an exemplary embodiment of a vibration damper in cross section;

Figure 1c shows an exemplary embodiment of a vibration damper in cross section;

Figure 1d shows an exemplary embodiment of a vibration damper in cross section;

Figure 2 shows a vibration damper in a halved longitudinal section;

Figure 3 shows a vibration damper ~~like that shown in Figure 2,~~
5 ~~but with~~ including radial stops;

Figure 4 shows a vibration damper ~~like that shown in Figure 2,~~
~~but with~~ including an external mass body; and

10 Figure 5 shows a vibration damper ~~like that shown in Figure 2,~~
~~but with~~ including rubber spring elements located on either side of the mass body.

Detailed Description of the Invention

15 ~~Figure 1 shows~~ Figures 1a to 1d show, in cross section, four different exemplary embodiments of a vibration damper for a propeller shaft tube 1 such as is arranged, for example, in the drive train of a motor vehicle. The four vibration dampers each comprise a mass body 51-53 that is mounted centeredly via
20 rubber spring elements 31, 32 in a sleeve 10, 15. The bonds between rubber spring elements 31, 32 and the respective sleeves 10, 15 as well as the mass bodies 51-53 belonging thereto are preferably created during vulcanization.

25 In the case of the exemplary embodiments ~~of the first two quadrants I and II~~ shown in Figures 1a and 1b, sleeves 10 are of cylindrical configuration. Mass body 51 is a cylindrical tube. It is retained, for example, by four rubber spring elements 31 in each case. Arranged between each two supporting
30 rubber spring elements 31 is a flexible rubber stop element 41. Stop element 41 of the exemplary embodiment shown in ~~quadrant I~~ Figure 1a is attached to mass body 51, while stop element 42 of the exemplary embodiment shown in ~~quadrant II~~ Figure 1b is retained on sleeve 10. In this case any lateral
35 movement of mass body 51 is prevented, for example, by a crimped-over sleeve edge.

Stop elements 41, 42 extend over a relatively large circumferential angle as compared to rubber spring elements 31, 32, i.e. they fill up a large portion of space 45 located between mass body 51, the adjacent rubber spring elements 41, and sleeve 10. As a result, the vibration travel in the central compression direction of a rubber spring element 31, 32 is only insignificantly greater than in the central compression direction of a stop element 41, 42.

Space 45 between each two adjacent rubber elements 31 has an almost circular cross section. The shape of rubber elements 31 resulting therefrom ensures an optimum bond with respect to metal components 10 and 51.

In ~~quadrants III~~ Figures 1c and IV 1d, a sleeve 15 having an undulating longitudinal profile is used. The longitudinal sections with respect to the profile shown here in cross section run parallel to the center line of propeller shaft tube 1. Because of the undulating shape of the profile, sleeve 15 is at least sufficiently elastic that it can be pressed without fit problems into propeller shaft tube 1. The residual clamping force of sleeve 15 necessary for a secure fit in propeller shaft tube 1 is ensured over the entire tolerance range for the inside diameter of propeller shaft tube 1. It is consequently possible to dispense with any special reworking of inner wall 2 of propeller shaft tube 1.

In ~~quadrant III~~ Figure 1c, there lies between rubber spring elements 32 a stop element 43, attached to mass body 52, that is at least partially adapted to the contour of an undulation trough 16. This adaptation allows damping of the torsional vibration of mass body 52. A rotation of mass body 52 with respect to sleeve 15 causes a reduction in the gap between stop element 43 and undulation trough 16, optionally to zero.

In ~~quadrant IV~~ Figure 1d, a mass body 53 that has the cross section of a four-sided polygon is used. The exposed polygon regions lie opposite the open undulation troughs 16 of sleeve 15. That is, the mass body 53 includes portions 60 that
5 project toward the troughs 16. To prevent any metal-to-metal contact between sleeve 15 and mass body 53, a thin rubber layer 44 or a layer of a comparable material is applied in each case between rubber spring elements 32. Rubber layer 44 prevents, inter alia, undesirable noise when mass body 53
10 abruptly deflects, and additionally damps any vibratory excitation resulting from this movement.

Figure 2 shows is a cross-sectional view of an exemplary
15 embodiment of a vibration damper having a cylindrical sleeve 10, a tubular mass body 51, and one of rubber spring elements 31 lying therebetween. The latter are narrower in the longitudinal direction than sleeve 10. The projection of sleeve 10 serves, inter alia, to protect the rubber spring and stop elements 31, 41, 42 during installation. Since the
20 vibration dampers are installed by inserting sleeves 10 into propeller shaft tube 1, the insertion tools must be placed against sleeve 10 so as thereby not to load rubber spring elements 31 upon insertion.

25 For axial retention, the vibration damper can be attached to the laterally projecting segments, for example, by way of spot welds on propeller shaft tube 1. Optionally, attachment to one projecting segment is sufficient. Alternatively, sleeve 10, 15 can be secured by way of center points punched into propeller
30 shaft tube 1 in front of and behind it. Instead of the center points, circumferential creases can be rolled in. The creases can also be applied only to portions of the sleeve circumference. It is furthermore possible to apply the vibration damper on one side to a shoulder in the interior of
35 the propeller shaft tube, or to jam the sleeve in place on an internal conicity which tapers there. The sleeve can moreover

be adhered in the propeller shaft tube by way of an adhesive bond.

In the case of propeller shaft tubes having a tube wall
5 manufactured with high precision, the sleeve can be joined by
way of a transverse press fit. In tubes having large bore
tolerances, a longitudinally slotted sleeve can be used. In
this context, a smooth or profiled rubber coating of the outer
contour is also conceivable in order to produce better
10 adhesion.

As shown in Figure 3, which is a cross-sectional view of an
exemplary embodiment of a vibration damper, rubber spring
element 33 is incorporated between a mass body 52 delimited by
15 rims 55, 56 and a sleeve 10 having a crimped edge 11. Rims 55,
56 and crimped edge 11 serve as radial stops. Upon radial
deflection of mass body 52, rim 55 comes into contact with
crimped edge 11, and rim 56 with the projecting cylindrical
segment 12. The contact zones can be covered with an elastic
20 coating.

Figure 4 shows an exemplary embodiment of a vibration damper
having a stepped sleeve 21. The segment with the greater
diameter is the installation segment 22. By way of this
25 segment, the vibration damper is retained in propeller shaft
tube 1. The segment with the smaller diameter is support
segment 23. On the latter, rubber spring elements 31 carrying
mass body 51 are arranged. Present between mass body 51 (which
in this case is cylindrical) and inner wall 2 of propeller
30 shaft tube 1 is a narrow gap whose width corresponds to half
the maximum excursion of mass body 51. In the event of an
imbalanced rotation of propeller shaft tube 1, mass body 51
conforms to inner wall 2 over a large contact zone. Mass body
51 is optionally coated on its external periphery with an
35 elastic material. The arrangement shown in Figure 4 may be

provided in conjunction with any of the exemplary embodiments shown Figures 1a to 1d.

Mass body 51 can also have the cross-sectional shape of a cup, so that it fits around carrier segment 23 of sleeve 21 (cf. cross-hatched widening of mass body 51). In addition, the mass body can have, for example, a cylindrical extension 59 at base 58 of the cup. The extension 59 would lie concentrically inside the external tubular segment 57 of mass body 51.

A second vibration damper having a configuration described in one of Figures 1 through 3 and 5 can furthermore be arranged in support segment 23.

Figure 5 shows an exemplary embodiment of a vibration damper whose rubber spring elements 34, 35 are loaded primarily in shear in the event of a radial deflection of mass body 51. This stress, which is favorable for the metal/rubber bond, is made possible by a sleeve 25 that is delimited at its end faces by, for example, planar disks 26, 27; a rubber spring element 34, 35 is arranged between each disk 26, 27 and mass body 51. Rubber spring elements 34, 35 are embodied here, for example, as continuous rings. Mass body 51, for example of tubular configuration, can carry a coating 44 on its external contour. In the exemplary embodiment, sleeve 25 is embodied as a bushing that is closed off by a spot-welded cover 27.

The central bore of the vibration damper facilitates manufacture, but is not absolutely necessary. Mass body 51 can optionally be widened, as illustrated in Figure 5 with cross-hatching.

Such widenings (cf. also Figure 4) have the advantage that the mass of the respective mass body 51-53 can be modified, with no change in the design of sleeves 21-25, in order to adapt the vibration behavior of the vibration damper to specific

interference frequencies of different propeller shaft tubes 1 having the same inside diameter.

5 Regardless of the location at which stop elements 41-43 are attached, the radial clearance of the individual mass bodies 51-53 in the corresponding sleeves or with respect to inner wall 2 of propeller shaft tube 1 is, for example, approximately 0.5 to 1 mm in terms of the inner radius of the sleeve or propeller shaft tube. Depending on the vibration
10 behavior of propeller shaft tube 1, the gap can have a defined dimension. As a rule, higher interference frequencies will require smaller gaps to prevent the imbalance of the combination of propeller shaft tube 1 and mass body 51-53 from becoming too great.

15 It should be appreciated that the arrangements shown in Figures 1a to 1d and in Figures 2 to 5 may be combined with each other in any desired combination. For illustrative purposes, Figure 1a and 1b include section lines II-II and
20 III-III to indicate that the arrangements shown in Figures 2 and 3 may correlate to the arrangement shown in Figure 1a or Figure 1b.

Abstract of the Invention

A vibration damper for a tubular propeller shaft in the drive train of a motor vehicle having a mass body mounted
5 concentrically, in the propeller shaft or in a sleeve attached in the propeller shaft, by way of at least one rubber spring element. Metal and/or flexible rubber stop elements that limit the vibration travel of the mass body at least in the radial direction are arranged between the mass body and the sleeve.
10 Alternatively, the mass body and/or the sleeve are configured at least locally, in mutually opposite regions, as stop elements that limit the vibration travel of the mass body at least in the radial direction.